GB- 1958-08

PATENT SPECIFICATION

863,928

DRAWINGS ATTACHED.

Date of Application and filing Complete Specification: *April 13, 1959.* *No. 12474/59.*

Application made in Norway on Aug. 4, 1958.

Complete Specification Published: *March 29, 1961.*

GT. BRIT. DIV. 37

Index at Acceptance :—**Class 39(3)**, H(1E : 2E4E : 2E11 : 3C).

International Classification :—H05b.

COMPLETE SPECIFICATION.

Improvements in Room Heating Elements.

We, NORSK ESWA A/S, of Welhavensgate 1, Oslo, Norway, a Company organized under the laws of the kingdom of Norway, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to electric room heating elements and more particularly to such elements which are adapted to be mounted in building structures adjacent room-confining faces for heating rooms of the building by radiant heat, such as by mounting in ceilings, walls or floors close to the side facing of the room to be heated.

Such elements of known design each comprise a resistor consisting of metal wire or foil of suitable electric resistivity attached to a supporting plate or sheet of insulating material such as a rigid sheet of wall-board or the like and are mostly covered by a protecting layer of impregnated paper or the like for protection against mechanical damage, water, etc. and/or for electrical insulation. An important requirement in use is that in order to afford a high degree of comfort and avoid any risk of fire the elements shall operate with a low over-temperature and cover relatively large areas of the confining faces, for instance the ceiling, so as to provide the necessary heating power with a low power consumption per unit of area covered, for instance a power consumption of about 100—200 watts per square meter. If metal wires are used for the resistors, it is relatively easy to make the elements in coilable form, which for reasons to be explained are preferable in many respects, but in regard to over-temperature they are objectionable since elements made with such wires will have a relatively low covering factor (area covered by the resistor divided by the overall area covered by the element) whereby the wire resistors will cause relatively high local heating and the wires, if damaged, may easily cause ignition of inflammable material such as paper adjacent thereto. If metal foil is used for the resistor, it will have to extend in a tortuous path in order to afford the necessary electric resistance, especially if each element or a few elements in series are to be connected directly to the mains voltage of for instance 220 volt. This however entails problems which have not been solved in a satisfactory manner by previously published proposals in so far as coilable elements are concerned. On the other hand coilable heating elements for the purposes described and having metal foil resistors are very desirable for various reasons.

Thus, apart from having the advantages inherent in metal foil resistors as compared with wire resistors such as reduced risk of fire and a high covering factor the foil resisters as such are easier to coil without damage than wires because of their small thickness, and the heating elements in the form of coilable mats, offer considerably increased facilities as regards flexibility in storing, shipping and handling the elements as compared with rigid elements. Thus, the latter will usually have to be made separately to order to suit the requirements in each particular case, partly because the dimensions of the rigid supporting plates must be adapted to those of the surface to be covered and partly because the plates will have to satisfy particular conditions as regards sound insulation and finishing, which is not necessary for a coilable mat, which will have to be covered by wall-board plates or other panelling on the side

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facing the room. In other words, with regard to this latter panelling the architect will be entirely free in his choice. Further, the placing of the resistor on a rigid supporting plate will mostly be dependent on the possible location of fastening means in each individual case in order that the resistor shall not be damaged in mounting, whereas a separate mat is capable of some lateral adjustment on the spot so as to make room for fastening means. Finally, it is of course important that coilable mats offer advantages with regard to storing and shipping as the mats may be stored and shipped in coiled condition or may be attached to coextensive or larger building sheets such as wall-board sheets or other rigid supports according to what is desirable in each individual case, while using mats kept in stock.

The reason why previously published proposals for providing a supporting layer with a resistance foil have not been satisfactory when the supporting layer is required to be flexible and the foil to extend in a tortuous path are due to the very small thickness required for the foil. Thus, both with a view to obtaining high flexibility of the foil and to keeping the costs low, it is important that the thickness of the foil shall be as small as consistent with the requirement that the foil must be capable of being manufactured commercially and the electric resistance per unit of length of a foil strip of any given width must be kept within tolerable limits of variation. Actually, as far as supply costs for the foil metal are concerned, it is practically only the thickness of the foil that counts, because for any given area of a mat of dimensions within reasonable limits and any usual mains voltage a desired heating power per unit of area, for example in the order of 100—200 watts per square meter may easily be achieved with a metal of convenient resistivity such as 0.1—0.2 Ohm mm^2/m by selecting the width of the foil strip and hence the length of the tortuous path so as to afford the required electric resistance. Now, a previous proposal consists in gluing a rectangular foil to a supporting layer and thereafter making slots in it so as to provide a tortuous path whereby the difficulties involved in handling of the very thin pre-cut foil are avoided. However, when using this method the cutting of the slots involves loss of metal and there is a danger of damaging the foil when cutting the slots, and above all it would be practically impossible to make the slots in the foil without damaging the supporting layer if this consists of a flexible sheet material such as paper.

It has also been proposed to apply the resistor metal in the form of an adhering paste to the supporting sheet. However, it is difficult by this method to achieve a satisfactorily uniform cross-section of teh remaining metal strip without resorting to troublesome machining operations, which would also involve loss of metal.

The present invention relates to an electric heating element of the kind described in which an electric heating resistor in the form of metal foil extends in a tortuous path and is supported by a sheet of flexible electrically insulating material, and has for an object to overcome the difficulties described. This is primarily achieved by providing the foil with a coextensive backing of flexible insulating sheet material firmly adhering to it and constituting with the foil a continuous strip, this composite strip being glued to said flexible supporting sheet.

Further, the invention relates to a method of producing flexible electric heating elements of the kind described which comprises applying to an adhesive-coated face of a sheet of insulating material suitable for forming a supporting sheet, a composite strip consisting of a strip of metal foil firmly adhering to a coextensive flexible insulating backing strip, said composite strip being applied successively in windings so as to follow a tortuous path while using an adhesive permitting successive application of the composite strip and alteration of its course.

When carrying out the invention uniting the resistor element with its supporting sheet is greatly facilitated due to the fact that the coextensive backing strip, which for example may consist of a thin and cheap sheet material such as paper, gives added mechanical strength to the foil so that it can easily be handled in strip form and applied to the sheet in the desired configuration. For instance a coil of the composite strip may be rolled back and forth on the adhesive-coated sheet, the strip being folded upon itself for each change of direction in the tortuous path. When doing this it is important to be able to effect alteration of the course of the strip immediately after applying it to the sheet so as to maintain a desired spacing of the lengths sufficient for insulating purposes but at the same time small enough for ensuring a satisfactory covering factor. With a view to this, one may use a glue that preserves a certain fluidity for a while after the coating process so as to permit lateral displacements of the strip adhering thereto. Or one may use a pressure- or heat-sensitive glue that has but a slight stickiness under normal conditions so that after applying the strip it is possible to detach portions of it from the sheet and put them back in new positions before final adherence is effected by a subsequent ironing operation. It is evident that for these adjustments to be made the increased mechanical strength of the resistor strip afforded by the paper backing is of great importance.

When applying the strip it is preferably folded at each point where the direction of the strip changes, along an oblique line with the insulating sides of the overlapping areas in mutual contact. Thereby, unduly sharp creasing of the foil at the folds is avoided and the overlapping areas of the foil are insulated from each other. This is of advantage since, although the voltage therebetween is very small and may seem unimportant, in the case of point contact of the overlapping areas experience has shown that excessive local heating might occur if the foil areas were placed in immediate contact with each other.

The composite strip may be produced at low costs and adapts itself to the most varying requirements. For producing the strips large sheets of paper and foil of a width many times those of the required strips may be unwound from appurtenant coils and united in a suitable continuous rolling operation so as to adhere firmly to each other, for example while using a pressure- and/or heat-sensitive glue for the adhesive. Or a suitable metal paste may be applied continuously to the moving paper sheet so as to adhere thereto in the form of a foil of suitable thickness. The resulting composite sheet may then be cut longitudinally, likewise in a continuous operation, into composite strips of the desired widths, which may then be wound into coils. These coils of desired standard widths may be kept in stock and used in desired lengths for making heating elements according to demand, whereby additional flexibility of the production is achieved.

Further advantages and features of the heating element and the method according to the invention will be apparent from the following description with reference to the accompanying drawings, in which :—

Fig. 1 is a plan view of a heating element according to a preferred embodiment of the invention with the covering sheet partly torn away;

Fig. 2 is a sectional view on an enlarged scale taken along the line II—II in Fig. 1 ;

Fig. 3 is a plan view on a relatively large scale of a mounting unit adapted to afford terminal connections to the element and used in the embodiment shown in Fig. 1 ;

Fig. 4 is a sectional detail view of the mounting unit as applied to the heating element, the section being taken along a broken line as indicated by IV—IV in Fig. 3 ; and

Fig. 5 is a diagrammatic perspective view on a small scale, indicating a possible manner of applying elements according to the invention to a ceiling.

In the embodiment illustrated in Figs. 1—4 the element 1 comprises the supporting bottom sheet 2, the composite resistor strip 3 and the covering sheet 4. The supporting sheet and likewise the covering sheet may consist of some flexible material of suitable strength and insulating and water repellent qualities, for example kraft paper coated with a moisture resistant lacquer, or a flexible artificial plastic material.

The strip 3 is applied in a manner described while using a suitable adhesive which may be identical with said lacquer, if the latter is suitable for the purpose, or a glue which is applied separately before the strip is applied. The strip extends back and forth in tortuous manner so as to form closely spaced parallel lengths, which, with a view to reducing the number of folds, extend in the longitudinal direction of the rectangular supporting sheet 2. As shown in Fig. 2 the strip is composed of a foil strip 5 and a backing strip 6 of paper, these components adhering firmly together and the foil 5 facing downwards in the longer lengths and upwards in the short transverse lengths at the extremities thereof. For each change of direction the composite strip is folded back on itself along an oblique line with the paper backing facing inwards as described. In order to make room for fastening means such as nails or the like, so that these may be passed through the element with the least possible risk of damaging the resistor, relatively large open spaces 7 of the sheet 2 are left uncovered by the resistor along the edges and likewise in a few intermediate areas 8 which extend in the direction of the longer lengths of the strip. The spacing of these open areas is preferably chosen with a view to corresponding with modules used in building structures for the spacing of spiking boards or laths, wooden framework elements or other elements in building structures, the spacings most frequently used being entire multiples of a foot or a decimeter.

For supplying current to the resistor it is important to use a terminal device which relieves the strip from tensional stress from the supply conductors and at the same time has a flat shape so as not to increase unduly the thickness of the element, and which involves no appreciable transition resistance in order to avoid undue local heating. For these reasons it is preferable to use some sort of soldering process, but in this connection it should be taken into account that the metal used for the foil, apart from having the desired resistivity and flexibility, should also have a relatively low melting point in order to melt away without causing danger if short-circuiting should inadvertently occur by the insertion of nails or the like. For satisfying these conditions a lead-tin alloy having a melting point of about 220° C., a thickness of about 0.015 mm. and a resistivity of about 0.15 Ohm mm.^{2}/m may be used, the melting point of 220° C. being sufficiently low for the purpose and at the

same time well above normal operating temperatures of the element.

With a view to providing a satisfactory connection to the resistor while taking these various considerations into account it is preferable to use a mounting unit 10 as illustrated in Figs. 1, 3 and 4. This unit comprises a pair of insulated electric conductor wires 11 which are surrounded by a common flexible protective tube 12 and at their inner extremities are soldered in conventional manner to flat terminal pieces 13 of a suitable metal or alloy having a relatively high melting point, such as brass. The soldering is effected on the lower side of the pieces 13 along one edge thereof, and in the proximity of the opposite edges, where the pieces 13 are bent slightly downwards as shown in Fig. 4, each of the pieces 13 has an area of its upper face coated with solder, which is indicated by cross-hatching 14 in Fig. 3, and which has a melting point considerably lower than that of the foil 5 but still well above the range of operating temperatures, for example a melting point of about 140° C. being suitable for the purpose. The terminal pieces 13 are attached, for instance by rivets 15 to a mounting strip 16 which may consist of a relatively strong insulating material such as laminated paper, cardboard or the like and is somewhat narrower than the pieces 13 so that the latter project outside the opposed longitudinal edges of the strip. This unit is mounted on the upper face of the supporting sheet 2, such as by rivets 17 passed through holes 18 in the strip 16 and corresponding holes in the sheet 2 and in a separate backing strip 19, which is applied to the lower side of the sheet 2 and may be somewhat larger than the strip 16 as indicated in Fig. 4 and with dash-and-dot lines in Fig. 3. The mounting of the unit described on the sheet 2 is so effected that the conductor leads 11 are pointing outwards and the unit is out of alignment with the open spaces 8 of the element. The mounting will normally be effected before the composite resistor strip is applied, and when applying the composite strip care is taken that the extremities of the composite strip will overlie the areas 14 of the terminal pieces 13 with the coil side facing downwards. Further, as shown in Fig. 4, these extremities are left free from adherence to the bottom sheet 2 for a certain distance and are plied into S-shape in the vertical plane for tension relieving purposes when they are finally soldered to the areas 14 of the pieces 13. For effecting the soldering operation pressure is applied to the extremities of the composite strip from above by means of a moderately heated tool, whereby the solder coating, but not the foil strip is melted.

The covering sheet 4, if any, is applied after the resistor has been connected to the mounting unit described and preferably also after the adhesive used for applying the composite strip has dried. A reason for this is that an intimate adherence of the covering sheet to the supporting sheet is often not desirable, since it might easily cause shrinking and consequent damage to the resistor if the mat is to be coiled up, which is mostly the case. For this reason, if a separate covering sheet 4 is used, it may be preferable merely to attach it to the bottom sheet by means of small strips of adhesive tape 20 at spaced points along the edges of the element.

However, a protective cover may be provided in other ways than that illustrated. For example, the entire supporting sheet carrying the resistor may be inserted into a flat sack of a suitable flexible and substantially waterproof plastic, whereby a better moisture protection is achieved. Or the strip may be applied to an adhesive-coated outer face of a sack of such material, serving as the supporting sheet, and the sack afterwards turned inside out so that the opposite layer of the sack will form a cover for the resistor. Finally a protective covering may also be made in the form of a coating of any insulating waterproof lacquer applied over the supporting sheet and the resistor. If desired, a sheet of crepe paper may be placed over the lacquer so as to adhere to the supporting sheet and resistor strip and contribute in keeping the latter safely in position. However, the use of a covering layer in the mat as produced and shipped is not absolutely essential in case the mat is stored and shipped in coiled condition and is to be applied with the resistor facing some electrically insulating plate or other structural element affording adequate protection in use.

Fig. 5 illustrates by way of example one manner of mounting the heating elements or mats made in accordance with the invention. In the example shown the element 1^1 may be similar to that shown in Fig. 1 with the exception that instead of having open areas 8 on either side of the central longitudinal axis of the mat a similar space is assumed to be provided along the center line and the terminal mounting unit is correspondingly displaced to one side of this line as indicated by the positions of the backing 19^1 and the sheath 12^1 for the conductors. The conductors extend into a connection box 21 in which they are connected to mains supply conductors passing through metal tubes 22, which extend transversely through and are supported by boards or laths 23 of the ceiling structure. The spaces between the laths 23 may be bridged by suitable heat insulating material such as flexible rock-wool mats 24. The spacing of the longitudinal open spaces within the mat 1^1 is assumed to be chosen in accordance with the module used for the spacing of the laths 23

and the mat is attached to these laths by nails or the like placed in the open areas. Finally, after all the heating mats of the ceiling have been attached and connected, they are covered at their lower side by suitable panelling used for the ceiling, indicated in the form of building sheets 25, which in the case illustrated are not coextensive with appurtenant mats but are placed in staggered relation and are but half as broad as the mats, but which can likewise be attached to the laths 23 by nailing and yet with practically no risk of damaging the resistors. It will also be understood that slight lateral or longitudinal displacements of the mats with a view to suiting specific requirements would easily be possible without disturbing the appearance of the ceiling.

However, the mats may be used in many other ways than that indicated in Fig. 5. Thus, as indicated previously it is possible when desired to attach the mats to coextensive or larger sheets used for the ceiling or wall etc., or between superposed sheets, and this may be done either in the factory or on the spot. Likewise, it is possible to combine the heating elements and heat insulation into pre-fabricated units, for instance by making a sort of wooden lattice frame to the lower side of which the mat and a covering plate therefor are attached so as to form the bottom of a resulting box-like structure, which may then be filled with some sort of insulating material, for example rock-wool.

WHAT WE CLAIM IS:—

1. A flat electrical heating element for mounting adjacent room-confining surfaces in buildings, comprising a supporting sheet of flexible, electrically insulating material, and a continuous composite strip glued to said supporting sheet in a tortuous manner and consisting of a metal foil electric heating resistor and a coextensive backing of flexible insulating sheet material firmly adhering thereto.

2. A heating element according to Claim 1, wherein said strip presents a plurality of substantially parallel main portions and end portions extending transversely of and shorter than said main portions.

3. A heating element according to Claim 2 wherein the foil side of said main portions faces the supporting sheet.

4. A heating element as claimed in Claim 2 or 3, wherein the marginal areas and one or more intermediate areas of the supporting sheet are left substantially uncovered by the strip for the insertion of fastening means.

5. A heating element as claimed in Claim 4, wherein said intermediate areas extend in the direction of the main portions of said strip.

6. A heating element as claimed in any of Claims 2 to 4, wherein the strip is folded along an oblique line at each point at which it changes direction, leaving the insulating sides of the overlapping areas in mutual contact.

7. A heating element as claimed in any of Claims 2—6, wherein said supporting sheet is of an elongated shape and the main portions of said strip extend substantially in the longitudinal direction thereof.

8. A heating element as claimed in any of Claims 1—7, wherein said supporting sheet has attached to its inner face a flat, electrically insulating mounting strip carrying a pair of terminals in the form of flat pieces of a metal of a relatively high melting point, each having an area of its exposed face coated with soldering metal of relatively low melting point as compared with the resistor metal, to which the ends of said resistor strips are soldered respectively with their foil side facing said areas, connector leads for current supply being likewise soldered to said pieces.

9. A method of producing flexible electric heating elements adapted for mounting adjacent room-confining surfaces in buildings, comprising applying to an adhesive-coated face of an insulating sheet material suitable for forming a supporting sheet, a composite strip consisting of a strip of metal foil firmly adhering to a coextensive flexible insulating backing strip, said composite strip being applied successively in tortuous manner, said adhesive permitting said successive application of the composite strip and alteration of its direction.

10. A method as claimed in Claim 9, wherein at each change of its direction the composite strip is folded upon itself about an oblique line with the backing strip inwardly of the fold.

11. A method as claimed in Claim 9 or 10, wherein the strip is applied in parallel courses joined at their ends by shorter transverse courses.

12. A method as claimed in Claim 11, wherein the strip is applied with its foil side facing the supporting sheet in the longer parallel courses and away from it in the shorter transverse courses.

13. A method as claimed in any one of Claims 9 to 12, wherein the composite strips are made by continuously applying to a moving sheet of backing material of a width considerably greater than that of the finished strips, a coextensive adhering metal foil resistor and severing the resulting composite product longitudinally into strips of desired width for subsequent use in making said heating elements.

14. A method as claimed in any one of Claims 9 to 13, wherein when applying the composite strip a few relatively large free

areas are left along the edges of the supporting sheet as well as intermediate the same, for the insertion of fastening means.

15. A method as claimed in any of the Claims 9—14, including the provision of a pre-fabricated unit for connecting a pair of current supply conductors to the ends of the strip of metal foil, comprising a pair of flat terminal pieces of a metal of a relatively high melting point, to which said conductors are soldered, which are attached to an insulating supporting strip and have on areas of their exposed faces, a coating of soldering material of a relatively low melting point as compared with the foil metal, mounting this unit on the inner face of said supporting sheet by attachment of the supporting strip thereto, applying the composite strip with the extremities of the foil facing the supporting sheet but not adhering thereto, and overlapping said areas of the terminal pieces respectively, when mounted, and pressing said extremities onto said areas while applying moderate heat so as to solder the same to said pieces.

16. A flat electrical heating element substantially as hereinbefore described and as shown in the accompanying drawings.

17. A method of producing electrical heating elements substantially as hereinbefore described with reference to the accompanying drawings.

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Abingdon : Printed for Her Majesty's Stationery Office, by Burgess & Son (Abingdon), Ltd.—1961.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2,
from which copies may be obtained.